

MODELLING MAGNETIC LEVITATION (MAGLEV) TRAIN

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ABSTRACT

‘Maglev’ represents magnetic levitation. The magnetically levitated train has no wheels, but floats on an electromagnetic wave. Maglev is trains that run on magnets in a certain way so that they are equally levitated. Maglev trains prove to be a promising technology in the future. The transrapid system uses servo mechanism to pull the train up from underneath the track and maintains a constant gap while travelling at high speed. Magnetically levitated trains may be the transportation of the future because of their advantages on modern transportation use today. As the train floats on the track, there is no contact with ground and need no moving parts, making the train a low maintenance affair. Their maintenance is less expensive than the conventional trains. Furthermore, there is no possibility of any parts wearing out and there is less noise because no steel wheels running on steel tracks. However, noise still occurred by air resistance. They are a lot better than the trains we used today and run almost as fast as an airplane. Also, these trains run on magnets, and therefore do not produce pollution, making them much more environmentally safe.

ABSTRAK

‘Maglev’(Magnetic Levitation) mewakili pengapungan atau pengangkatan magnet. Kereta api Maglev tidak mempunyai roda dan bergerak dengan terapung di atas gelombang elektromagnet. Maglev adalah kereta api yang bergerak di atas magnet dengan cara tertentu supaya terapung sepenuhnya. Kereta api Maglev terbukti menjadi satu teknologi yang canggih di masa hadapan. Sistem Transrapid menggunakan mekanisma servo dengan menarik kereta api dari bawah trek dan mengekalkan jurang semasa pergerakan pada kelajuan yang sangat tinggi. Kereta api Maglev menjadi pengangkutan yang akan digunakan pada masa hadapan kerana kelebihan mereka pada penggunaan pengangkutan moden hari ini. Ia terapung di atas landasannya, tidak bersentuh dengan tanah dan tidak memerlukan bahagian yang bergerak, menyebabkan kos penyelenggaraan yang rendah. Penyelenggaraan mereka adalah kurang mahal daripada kereta api konvensional. Tambahan pula, tidak ada kemungkinan mana-mana bahagian akan tercabut dan mengeluarkan bunyi bising kerana tiada penggunaan roda keluli di trek. Walaubagaimanapun, bunyi bising masih terhasil oleh rintangan udara. Banyak kelebihan terdapat pada kereta api Maglev berbanding daripada kereta api yang kita gunakan hari ini dan ia bergerak hampir laju dengan kelajuan kapal terbang. Akhir sekali, kereta api Maglev tidak menghasilkan pencemaran udara, menjadikan mereka teknologi yang lebih mesra alam.

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LIST OF ABBREVIATION

V	Voltage
LED	Light Emitting Diode
LM298	Dual Full Bridge Motor Driver
LM7805	Voltage Regulator
DC	Direct Current
PIC	Peripheral Interface Controller
IC	Integrated Circuit
VDD	Supply Voltage
VSS	Ground
RPM	Revolution Per Minute
IR	Infrared
RF	Radio Frequency

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CHAPTER 1

INTRODUCTION

1.1 Introduction to Maglev

The idea of Maglev transportation has been around since the early 1900s. The benefit of eliminating the wheel/rail friction to obtain higher speeds and lower maintenance costs has great appeal. The basic idea of a Maglev Train is to levitate it with magnetic fields so there is no physical contact between the train and the rails (guide ways). There are three primary functions basic to maglev technology: levitation or suspension, propulsion and guidance. Figure 1.1 shows the three main concepts about Maglev Train: propulsion, levitation and guidance.

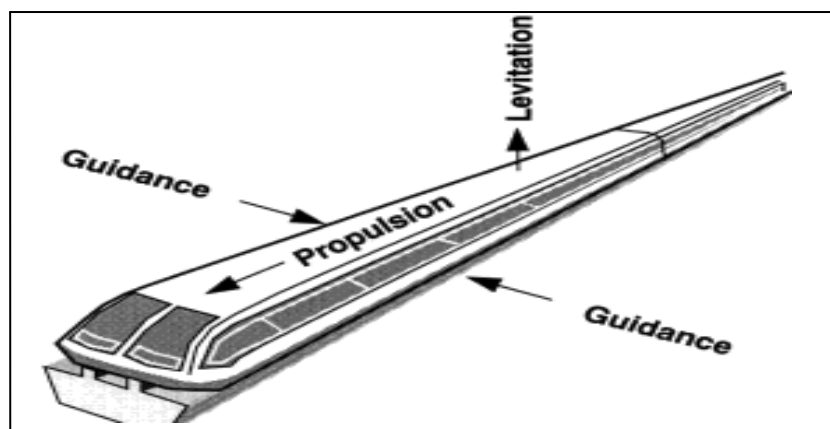


Figure 1.1: Three main concepts about Maglev Train

1.11 Suspension Systems

German engineers had developed Electromagnetic Suspension (EMS) while Japanese engineers had developed Electrodynamic Suspension (EDS), the newest EDS technology is the Inductrack. There are three basic different concepts of magnetic suspension have evolved.

- 1) The attractive Electromagnetic Suspension (EMS) uses electromagnets on the train body which are attracted to the iron rails. The vehicle magnets wrap around the iron guideways.
- 2) The Electrodynamic Suspension (EDS) levitates the train by repulsive forces from the induced currents in the conductive guideways. Electromagnets on the guideway levitates the train.
- 3) The Inductrack concept that is permanent magnets levitates over passive coils.

In magnetic levitation, basic principles is used to suspend vehicles weighing 40 tons or more by generating a controlled magnetic force. Figure 1.1 shows the image of levitation techniques that is Electrodynamic, Electromagnetic and Inductrack.

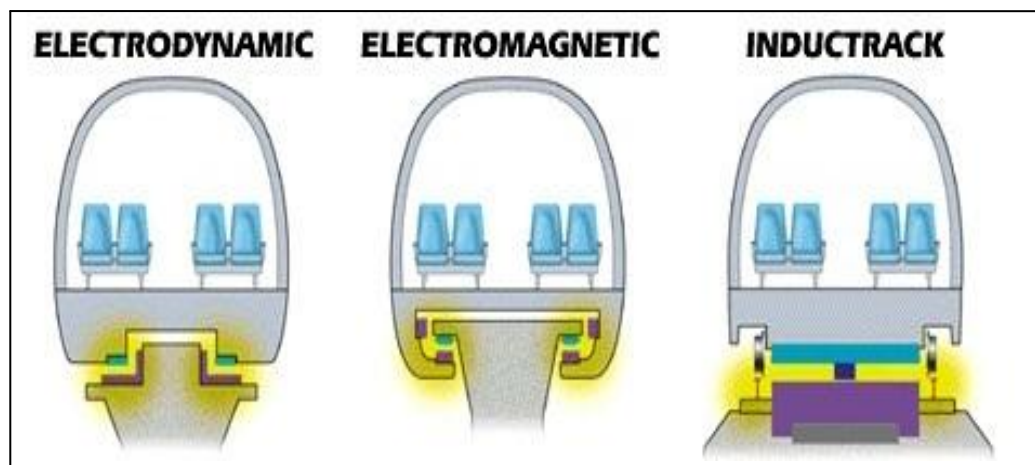


Figure 1.2: The types of Levitation for Maglev Train

However, there is a fundamental difference between these two systems. In the EMS system, the air gap between the guide ways and train magnets is very small ($\sim 1/2$ inch), whereas the air gap in the EDS system may be as large as 8-10 inches. The small air gap of the EMS system implies much more stringent controls to maintain this small gap. The superconducting magnets that have been used in these MAGLEV systems have been of the low temperature variety. Because these must be operated below liquid helium temperature (4.2 K) these are expensive and complex systems [1].

Magnetic levitation is a process by which a magnet over a piece of a metal causes electrical current to flow in the metal that, in turn, produce forces that push the magnet upward. If the force is large enough, the moving magnet can levitated. Magnetic levitation is used in a new generation of train that will have cruising speeds of up to three hundred miles per hour [1].

1.12 Propulsion Systems

Long-stator propulsion using an electrically powered linear synchronous motor (LSM) winding in the guide way appears to be the best known option for high-speed maglev systems. It is also considered the more expensive option because of perceived higher guide way construction costs. Short-stator propulsion uses a linear induction motor (LIM) winding on board and a passive guide way. While short-stator propulsion typically reduces guide way costs, the LIM is heavy and reduces vehicle payload capacity, resulting in higher operating costs and lower revenue potential compared to the long-stator propulsion. A third alternative is a nonmagnetic energy source (gas turbine or turboprop) but this show results in a heavy vehicle and reduced operating efficiency [2].

A maglev train system has three basic components: a large electrical power source, metal coils lining the walls and the track, and large guidance magnets which are attached to the bottom of the train. The power source is then able to create a magnetic field in the electrified coils along the track.

Then, the magnetic field along the track repels the train so that it levitates above the ground while the magnetic field in the walls attracts and repels the train to move it along the designated path [2]. Figure 1.2 shows how the maglev train moves along the track.

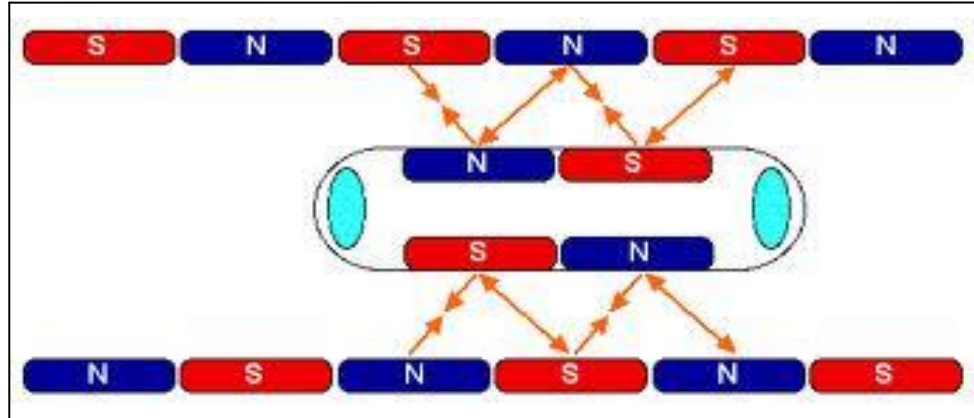


Figure 1.3: Magnetic field that move the train forwards.

The big difference between a maglev train and a conventional train is that maglev trains do not have an engine. The engine for maglev trains is rather inconspicuous. Instead of using fossil fuels, the magnetic field created by the electrified coils in the guide way walls and the track combine to propel the train [3].

The entire maglev system is control by operation control system. Operational control system is the fundamental guarantee for the normal operation of the whole maglev system. It includes all the equipment to be used in security guarantee control, execution and plan and also includes the equipment to be used in communication among the equipment. Operation control system consists of operation control center, communication system and on-board control system [3].

1.13 Guidance system

Guidance or steering refers to the sideward forces that are required to make the vehicle follow the guide way. The necessary forces are supplied in an exactly analogous fashion to the suspension forces, either attractive or repulsive. The same magnets on board the vehicle, which supply lift, can be used for guidance or separate guidance magnets. Figure 1.3 shows the magnets to guide the maglev train at guide ways [4].

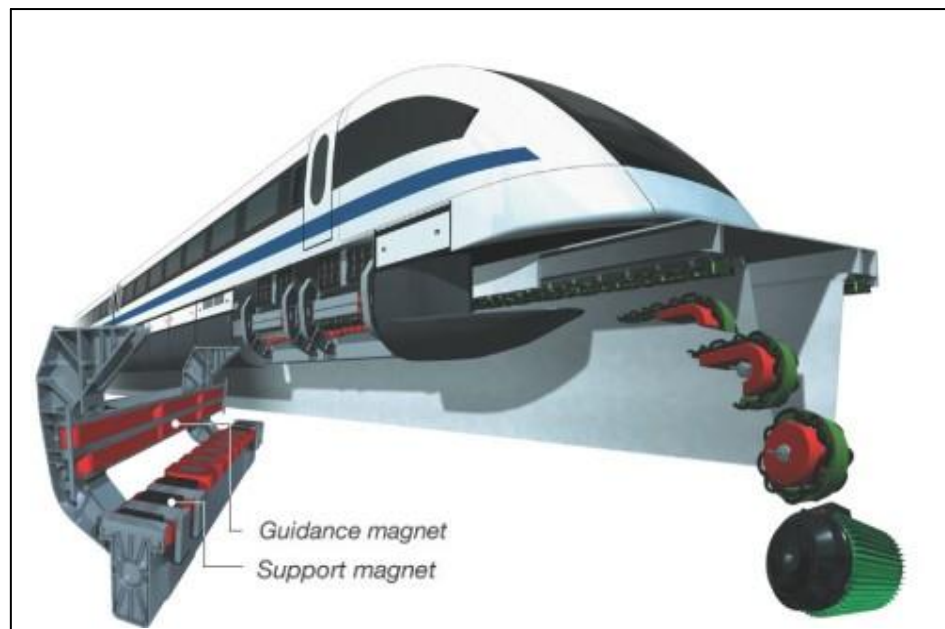


Figure 1.4: Magnets for Maglev Train guidance

1.2 Problem Statement

The material to do the model of Maglev Train is high as the costs for magnets are expensive. Magnetic force of the magnet must strong enough to levitate the model train. The cost of modeling maglev system using superconducting is very high because of superconductor itself is very expensive.

Also, to control the speed of train, a controller is needed. There must have a controller that is connected to the maglev system.

Large current through the motor is also needed in order to create enough thrust force and drag force to propel the model train forward. If the current is not enough, the train will not propel along the track.

1.3 Objectives

The objectives of this project are

- I. To create a less expensive model of Maglev Train
- II. To control the speed of the Maglev Train by using PIC (Microcontroller)
- III. To study the difference between superconducting maglev and electromagnetic maglev.

1.4 Scopes of Project

The speed of the model maglev train is controlled by PIC that indicates three different speeds. First speed is slow, second speed is fast, and third speed is very fast..

Next, the PIC only controls the speed of DC motor and cannot control the direction of the DC motor.

Lastly, the model of Maglev Train can't be applied in real life. For modelling Maglev, inside of the body of train it's self are created including putting some magnet. However, if it applied to the real maglev, those materials that are made of magnets and have different pole at surrounding or inside the train will attract to the body of the train.

1.5 Outline of Thesis

This modelling of Maglev Train final thesis consists of five chapters including this chapter. The content of each chapter are outlined as follows:

<i>1- Introduction</i>	Introducing the overview of project including the background, objectives, problem statement, and scope of the project.
<i>2-Literature Review</i>	Before starting the project, the background and literature review about modeling of maglev train has been studied in order to understand more about the operation and principle of this project.
<i>3-Methodology</i>	This chapter will explain how the project was organized and the flow of system designed. Before developing the prototype, the simulation has been done

to make sure that the circuit would be working properly.

4-Result and Discussion

The result will be analyzed and discussed in this chapter. It will shows the result achieved by doing this project. The results are categorized into three parts; hardware, software and analysis of the system.

5-Conclusion

The overall conclusion of this project that has been addressed in this chapter including future work of the project. The future works are recommendation and suggestions made for the project to be improved in near future.

1.6 Gantt Chart

Gantt chart and the details for this project that had been implemented for the first and second semester are shows in APPENDIX. Gantt chart for semester one is APPENDIX D whereas semester two is APPENDIX E.

CHAPTER 2

LITERATURE REVIEW

2.1 Modeling of Maglev system

2.11 Control of Magnetic Levitation System Using Fuzzy Logic Control

In this study, it has been observed that the basic design of Maglev's is an arrangement of electromagnets placed on top of the plant and makes the ball levitated in the air. The modeling system is simulated using MATLAB Simulink. This paper presents the comparison output for both PID Controller and Fuzzy controller to control the ball levitate on the air. The focus of this study is to design the controller that can cope with Maglev's which highly nonlinear and inherently unstable [5].

2.12 Modeling of a flexible rotor maglev system

The modelling takes into account the three main behavioural characteristics of such magnetically-levitated rotor: the rigid dynamics, the flexible dynamics and the rotating unbalanced motion.

Using this model, a stabilizing controller has been successfully designed for the system and a complete experimental analysis of its performance is carried out [6].

2.13 Propulsion control of superconducting linear synchronous motor vehicle

In this journal, it stated that the armature current of a superconducting Linear Synchronous Motor (LSM) for a maglev vehicle is controlled to produce a suitable propulsion force so that the vehicle follows the reference speed signal sent from a control station. Besides that, the power is supplied from some inverters to the LSM armature sections where the vehicle exists. This paper shows an exact mathematical modelling of the propulsion control system to treat the system analytically, which is used for designing controllers and performance computer simulations. The calculated results include the simulations when the vehicle goes through power feeder section borders and tunnels that have a large aerodynamic drag force with taking account of an inverter failure [7].

2.14 Maglev Train (Superconducting Maglev)

It introduces superconductors and their usage in the modern world, as well as to the Meissner's Effect and the idea of magnetic levitation. It is a mesmerizing demonstration that can be kept and used indefinitely, as long as more liquid nitrogen is supplied. The Maglev Train achieves levitation through the phenomenon of superconductivity. Superconductivity occurs in special materials when they reach their critical temperature, which in this case is 107 K (-166 °C). The main feature of superconductivity is the absence of resistance to an electrical current, called a zero-resistance state. In regular materials, the movement of electrons is restricted and an electric potential must be applied in order to create moving charge. Superconductors in the zero resistance-state allow electrons in the material to move free of impedance. Since current is moving charge (electrons), superconductors are able to carry current with almost infinite conductivity [8].

2.15 A maglev system: modeling and controller design

In this paper, the nonlinear mathematical model with five DOFs (degrees-of-freedom) of a magnetic levitation system is developed and analyzed. Then a second order sliding mode controller is proposed to regulate the levitation to a desired position, stabilize the other four DOFs in the nonlinear system and compensate the unknown increments on the load. Simulation results are presented to show the effectiveness of the proposed controller. The transport of material or products is a major problem in the manufacturing automation industry. As it currently stands transport specifications can be so variable from process within a single plant that each operation might require its own transport. Using magnetic levitation (maglev), a carrier can be partially or totally levitated or suspended by magnetic fields generated along the guiding tracks. This allows the carrier to move with little or no contact to the guiding tracks, thus greatly minimizing the problems of environmental contamination. Of course, such contact-free levitation has to be enforced for all DOFs of the rigid body [9].

2.2 PIC controller

2.21 Development of Motor Controller Based on PIC

This paper presents a motor controller based on PIC. Deferent from the traditional regular control pattern, the motor controller adopts changeable control pattern that enables a robot to use the different control mode according to the different external environment. The hardware, software architecture, algorithm of motion control, calibration, position limit, and communication are described. The experiments of position, velocity and current control are given, and the application of the motor controller is introduced [10].

CHAPTER 3

METHODOLOGY

3.1 Overview Maglev System

There are two main things for this modelling of Maglev Train which are model of the train and model of the track. Budget on doing these model are the lowest as possible. The train are controlled by PIC microcontroller to adjust the speed of DC motor. Small fan is attached to the DC motor and act just like the fan of airplane. Then, the maglev track is made by using thin plywood and lots of high magnetic strength magnet. The shape of the track is oblong shape. Suspension magnet is attached under the model of the train. The arrangement and ordering of the guidance magnet at track and train must be at same polarity. This is because of same pole of magnet will repels both of magnets and caused the model train to float (levitates) at the model track.

3.2 Hardware development

The simulation part should be running before doing the hardware part in order to make sure that the circuit can operate correctly and achieve the purpose of the project. This part is important because by doing simulation, the fault on the circuit can be safely determine without use the real components. If the prototype is developed without doing the simulation, any failure of the circuit will cause the damage on the components. Therefore, more budgets needed to buy new components. By doing this simulation, the budget of the project can be minimized and components damage can be avoided. Figure 3.1 shows the process of hardware development.

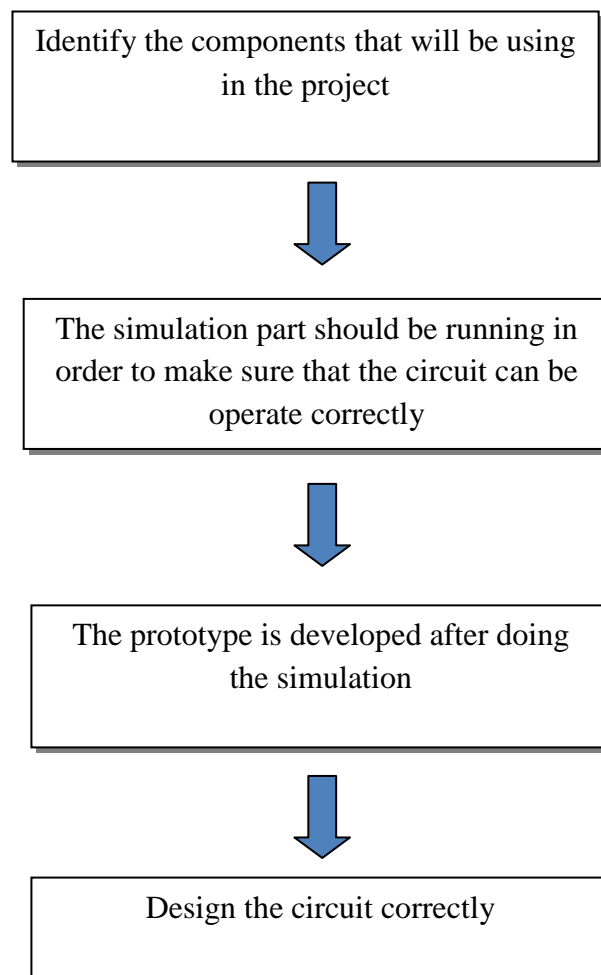


Figure 3.1: Process of Hardware Development

For this project, the software that has been used is:

- i. Proteus – ISIS
- ii. PIC KIT Controller
- iii. PIC C Compiler

3.2.1 Track Modelling

The model of the track is made by plywood and a lot of magnets. Base of the track is 120cm x 70cm plywood. Area of the track for maglev train to propel is 100cm x 50cm. The shape is oblong shape. Magnets are arranged along the track and around two hundred magnets are used. AUTOCAD Software is used to design the model track. Figure 3.2 shows the plywood after been glued with strong gum (Dunlop General Purpose Contact Adhesive gum).



Figure 3.2: Oblong shape of maglev track model

3.2.2 Train Modelling

The model of the train is made of simulation circuit that attached to plywood as the base of the train. Magnets are glued at the bottom of the plywood. It will levitate at track because of same polarity with the magnets arranged at model track. Figure 3.3 shows the circuit of model train.